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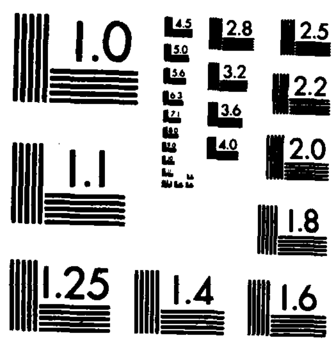

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THE STRUCTURAL STRATEGIES MODEL

NAVY PERSONNEL RESEARCH
AND
DEVELOPMENT CENTER
San Diego, California 92152

NPRDC Technical Note 82-18 May 1982

THE STRUCTURAL STRATEGIES MODEL

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It is generally accepted that the subject matter of many fields has inherent organization or structure such that, if reliably identified, would permit the development of more efficient instructional procedures. This research proposes an approach for identifying/developing major types of structures (taxonomies, hierarchies, theories, or models) and for organizing and sequencing subject matter within and across structures.

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FOREWORD

This research and development was conducted, in part, under contract N00123-76-C-0245 with Courseware, Inc. in support of exploratory development task area ZF55-522-002 (methodology for development and evaluation of Navy training programs), work unit 03.33 (practical problems in the implementation of individualized instruction). It was sponsored by the Chief of Naval Education and Training. The objectives of work unit 03.33 were to identify factors that militate against the effectiveness of self-paced instruction and, where appropriate, initiate research to improve conditions.

Research on structural strategies is based on the premise that knowledge in a field may be analyzed into different kinds of units for which optimal instructional strategies may be identified. This report presents a summary and evaluation of a model developed by the contractor for identifying, selecting, sequencing, and synthesizing large units of material, taxonomies, hierarchies, and theories or models. It is hoped that this publication will stimulate further research and development in this area of instructional technology.

The contracting officer's technical representative for the contractual development of the structural strategies model was Dr. John P. Smith. Co-author Dr. Charles M. Reigeluth, formerly of Courseware, Inc., is currently with Syracuse University, Syracuse, New York.

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SUMMARY

Problem

Marked differences may be observed in the way subject matter is organized and presented, even within similar technical content areas. Apparently, these differences result largely from the disparate procedures employed in developing training materials. Existing procedures for organizing the content of a subject by identifying its major elements or structures and for guiding the development of content around these structures are inadequate. New conceptual and analytic techniques addressed to the organization and emphasis of major subject matter elements are needed.

Objective

The objectives of this research were (1) to develop reliable methods to identify the important kinds of subject matter structures and (2) to suggest optimal instructional strategies for these different structures.

Approach

It was assumed that structural strategies were among the major variables that must be included in a general model of the instructional process. Thus, a model for identifying, sequencing, and synthesizing structures was developed, and steps to be taken to apply the model to a body of subject matter were described. A body of technical material was then analyzed, major structures were identified, and procedures for sequencing and synthesizing this material were illustrated.

Results

Compared to the existing course materials, the illustrative materials were substantially different in organization, especially in the use of important theoretical material to orient students to the content.

Conclusions

The structural strategies model described herein is an attempt to improve effectiveness of instruction by specifying methods to identify and organize important relationships in subject matter. Although some of the procedures and concepts have value for instructional development, the model is not fully adequate in its present form.

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INTRODUCTION

Problem

Navy training costs are increased by high attrition rates or excessive training time. Previous investigations indicated that inadequacies of the training materials contribute to these costs (Smith & Bilinski, undated).

Training materials may be inadequate in various ways, including choice of subject matter and organization. Many courses compound these inadequacies by following an exhaustive, detailed, linear presentation, apparently with the objective of conveying stores of detailed information for later recall and application. This approach ignores important relationships between topics, requires brute force memorization, overloads processing ability, provides no context for retrieval, and demotivates through tedium and the absence of application.

Objective

The objectives of this research were (1) to develop reliable methods to identify the important kinds of subject matter structures and (2) to suggest optimal instructional strategies for the different structures. The present report describes a model that was developed under contract (Reigeluth, Merrill, Wilson, & Spiller, 1978) in an effort to provide a strategy for sequencing and synthesizing technical training course materials.

Background

Instructional technology literature was reviewed for alternatives to provide guidance for better instructional practice. However, proven methods of organizing large units of complex subject matter for ease of learning and good retention have not been reported.[1]

The various models for developing instructional materials recognize the importance of good organization, but instructional technology has yet to develop effective guidance for achieving good organization. Here, for example, is the guidance on sequencing in CNTT A-10 (CNTT, 1976):

> 3.0 SEQUENCING OBJECTIVES
>
> Sequencing Learning Objectives is an incremental building process that will ensure the student the opportunity to acquire knowledge and skills specified in Enabling Objectives prior to being required to demonstrate the ability to perform the terminal behaviors of the course.
>
> The course content must be sequenced in an order that facilitates the students' achievement of the Learning Objectives.

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[1]The instructional quality inventory (NPRDC SR 79-3) provides clear and detailed guidance for the course writer or lecturer to follow when presenting small units of knowledge (e.g., facts, concepts, principles).

Many factors must be considered when accomplishing the sequencing process. Among them are traditional considerations such as known to unknown, simple to complex, a whole to its parts, or parts to a whole, and consideration based on newer concepts such a matrix analysis, learning domains, and logic and motivation orders. Research is being conducted at present in the latter areas and further information can be obtained by studying references from the Additional Reading List for the Manual.

Through rational analysis, a tentative sequence will be determined for the course; the determination of the final sequence will be made during the validation phase of the course development process as discussed later in this section of the manual.

The Interservice Design Manual (CNET, 1979) correctly observes that sequence concerns prerequisites and common skills, and emphasizes subject matter relationships (see Table 1). The hierarchy is the only subject matter structure identified by this resource, which also specifies a detail-to-part-to-whole type of sequencing. While the emphasis on relationships is vital, it is not necessary to teach them by proceeding from the detail to the whole. The model described in this report can be read as an attempt to strengthen the focus on relationships by developing analytic and sequencing procedures.

Table 1

Types of Relationships Between Learning Objectives

Dependent	Independent	Supportive
Skills and knowledges in one learning objective are closely related to those in the other learning objective.	Skills and knowledges in one learning objective are unrelated to those in the other learning objective.	Skills and knowledges in one learning objective have some relationship to those in the other learning objective.
To master one of the learning objectives, it is first necessary to master the other.	Mastering one of the learning objectives does not simplify mastering the other.	The learning involved in mastery of one learning objective transfers to the other, making learning involved in the mastery of the other easier.
<u>Examples:</u> In math, in order to learn multiplication one must first learn addition. One cannot send messages in Morse Code without first having mastered the codes for each of the letters and numbers. The "sending" skills are totally dependent on the prior learning.	<u>Examples:</u> For a yeoman, "type letters from drafts" is independent of "maintain files." For a wheeled vehicle mechanic, "adjust carburetor" is independent of "torque engine head studs." In both examples, knowing how to do one would not help much with the other.	<u>Examples:</u> "Assemble weapon" has a supportive relationship to "disassemble" weapon." "Drive a 1/4 ton truck" has a supporative relationship to "drive a 2 1/2 ton vehicle." In both examples, learning to do one would help considerably in learning to do the other.
The learning objectives must be arranged in the sequence indicated by the above hierarchy.	In general, the learning objectives can be arranged in any sequence without loss of learning.	The learning objectives should be placed close together in the sequence to permit optimum transfer of learning from one learning objective to the other.

DEVELOPMENT OF THE STRUCTURAL STRATEGIES MODEL

Knowledge Structure

The motivation for analyzing knowledge into structures is that, if different structures can be reliably identified, efficient and economical instructional prescriptions can be established regardless of the particular content or subject matter. The structural strategies model, hereafter called "the model," proposes that knowledge be categorized as identities (e.g., facts, data), concepts, combinations of concepts called constructs (e.g., rules, principles), and combinations of constructs called structures. This model concerns the structures, further identified as (1) taxonomies, showing superordinate, coordinate, or subordinate relationships, (2) hierarchies, showing prerequisite relationships, and (3) theories or models, showing causal relationships. The rationale for the classification of knowledge into these constructs and structures is given in Appendix A, and examples are provided in Figures 1 through 4.[2]

Structuring Strategies

Taxonomies, hierarchies, and models, with their expressed and implied relationships are the major structures concerned with the strategies of selecting, sequencing, synthesizing, and summarizing. These strategies are described in the following paragraphs:

Selecting: Identifying and Developing the Structures

To identify the major structures and further categorize them in terms of their relationships to each other, the subject matter expert (SME) identifies the following:

1. Orientation structure. This is a structure so inclusive it subsumes most of the subject matter to be taught. Orientation structures may be conceptual (taxonomies), procedural (hierarchies), or theoretical (models).

2. Supporting structure. This is a less inclusive structure, providing knowledge that contributes to understanding the orientation structure. It also may be conceptual, theoretical, or procedural. Two supporting structures may be related or parallel, as in the case of a procedure and the rationale for performing and interpreting it. Figure 5 is an illustration of a conceptual supporting structure.

3. Learning prerequisite structures. Any relevant information presupposed by any other structure.

Next, the SME must (1) determine the type of orientation structure, (2) develop the orientation structure, and (3) determine the supporting and prerequisite structures. To do this, the SME must be comfortably familiar with the concept of different structures and extremely knowledgeable of the subject matter. Also, he must be able to set aside his preconceptions concerning appropriate content and organization of training material. This sequence of steps is described below.

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[2]Because of the large number of figures in this section relative to the amount of text, the figures are presented at the end of the section, commencing on page 8.

1. Determine the type of orientation structure. A conceptual orientation structure is most appropriate if the emphasis of the course is on learning a large set of related concepts. If the emphasis is on learning a generally standardized or routine performance--one that occurs with only slight variations--a procedural orientation structure is most appropriate. (This type of structure is relatively infrequent, as fe ' courses are designed solely or mainly for such simple subject matter.) If the emphasis is on learning a set of underlying processes or principles that enable the trainee to interpret phenomena or solve problems, a theoretical orientation structure is appropriate.

To illustrate the model, it was applied to the material of the Basic Electricity and Electronics (BE/E) course (course file 69).[3] The basic part of this course (modules 1-14) includes concepts, procedures, and principles. Ultimately, knowledge obtained is used to evaluate systems, decide on necessary maintenance actions (including malfunction diagnosis), and verify that faults are corrected. Efficient performance of these major tasks calls for flexible and intelligent judgment based, among other things, on understanding electrical and electronic circuit phenomena. Since the explanations of such phenomena are theoretical (see Figure 6), it was determined that the orientation structure for this course should be theoretical.

2. Develop the orientation structure. The three types of orientation all involve a slightly different developmental approach. For the theoretical orientation structure, the SME must first identify all the principles that the learner must know in order to be able to perform as required by the objectives.[4] To do this, the SME identifies an elementary set of principles, or model, upon which all other principles elaborate. For the BE/E course application, Ohm's Law (Figure 4) was identified. The SME then identifies the other principles that provide more detail or complexity to the elementary model until they are adequate to achieve the objectives. Figures 7 and 8 show principles and theoretical relations developed in this analysis.

For the conceptual orientation structure, the SME must understand the taxonomic ideas of superordinate, coordinate, and subordinate relations among concepts, and the ideas of parts-ordinate and kinds-ordinate varieties of those relations (illustrated in Figures 1 and 2. To begin, he must identify the most general concept in the subject matter area to be taught. This will usually be represented in a very general way (e.g., electronics, oceanography, welding, etc.). The label is written at the top of two separate sheets of paper. The SME then divides the heading concept into its most general parts, and writes them below the heading on the other sheet of paper. He also divides the concept into its most general kinds, and enters them on another paper. The SME continues to derive the parts and kinds taxonomies separately until enough detail has been arrayed to achieve the objectives. One taxonomy will become the orientation structure; and the other, a supporting structure.

For the procedural orientation structure, the SME must understand the concepts of procedural prerequisite relation and procedural decision relation. These are illustrated in Figures 9 and 10 respectively. The SME must identify all of the steps that the learner needs to be able to do in order to perform the procedure under the variety of conditions specified by the objectives. Initially, the SME gives a very general procedure that subsumes all of the steps to be taught. He then systematically breaks down each step of

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[3]Course File 69 has been superseded by a later version of the BE/E course.

[4]The existence of adequate objectives is assumed at this point. Later, it will be said that this may be an unsafe supposition.

that general procedure into its major parts and alternatives, and each of them into major parts and alternatives, and so on until the level of detail needed to accommodate student knowlege and the level of complexity specified by the objectives is reached. If there are several procedures for doing the same thing under the same conditions, only the most efficient are included.

3. Determine the supporting and prerequisite structures. Supporting structures are all those that are not direct parts of the orientation structure. The general nature of the relationship between orientation and supporting structures is diagrammed in Figure 11. Different structures, including supporting structures, are listed in Figure 12. Examples of time constants, types of circuits, various subroutines, meters, thought problems such as variational analysis, and troubleshooting are provided in Figures 13 through 18 respectively. The supporting structures must be further examined to determine whether trainees need additional instruction for prerequisite knowledge.

Sequencing: Whole-to-Part Approach

An extensive and complex subject may be presented by accumulating details, as in the linear model described earlier. This is called part-to-whole teaching. The detail of each subtopic is exhausted before the next is taken up, and the interrelationships and applications are left until all topics are covered, sometimes until a later course in the training pipeline. (Introductory, intermediate, and advanced course sequences illustrate this common approach.)

In contrast, whole-to-part teaching (1) presents a general, global account of the subject, (2) separates the whole into major topics, and (3) breaks the topics down until the entire subject has been covered. The explicit intent of the whole-to-part approach is to ensure comprehension of the general nature and important ideas and interrelationships in the entire subject. Detail is an objective of instruction only when it contributes to comprehension of the meaning of the major content elements. The stress on interrelationships in the whole-to-part approach usually means that the ideas are traced through topics; therefore, topics are not treated exhaustively in one "pass" but are returned to several times in a multipass or "elaboration" type of organization. The model presents a multipass, whole-to-part approach, in which the instruction is elaborated through increasing levels of detail. Figure 19 is a procedural prerequisite structure (flow chart) that illustrates this concept of course organization. Sequencing concerns the order within each level and also the allocation of material to levels.

The elaboration of material of the different levels once again involves the SME in analysis of the content, this time to determine the elements of each structure that will be presented at each level of elaboration or "pass" through the material. The epitome is a brief statement that expresses the most important ideas of the orientation structure. For example, in basic electricity, the most important ideas are those that concern the interactions of voltage, resistance, and current. The epitome would express these interactions in some convenient way (e.g., $I = \frac{E}{R}$). This epitome is followed by the first level of elaboration; in this case, a discussion of the interactions signified by the equation. At the second and lower levels of elaboration, each statement in the first level is amplified, and detail is added where needed.

Deriving the levels of elaboration requires deciding upon dimensions of complexity that represent the basis upon which the different levels elaborate on the epitome or on each other. Also, those dimensions of complexity must be analyzed to determine the order in which the different kinds of detail or complexity will be presented in the instruction.

The result of this step is an outline of the subject matter content to be included in the epitome and in each level of elaboration. The specific procedures for this analysis are as follows:

1. Theoretical. Given the decision that the interactions of circuit phenomena are the most fundamental theoretical relations in electricity and electronics, Ohm's Law was selected as the epitome. To distinguish the different levels of elaboration, the SME lists the remaining principles in decreasing order of importance, as in Figure 7. Importance was estimated based on how much each principle contributed to understanding the whole theoretical structure. Principles of about the same order of importance are merely grouped on a single level. The SME and the designer then allocated the principles to levels by tracing the important relationships, interpretations, or applications through the various topics to which they are related. In following this procedure, detail is left for lower levels of elaboration whenever possible. This is because the intent is to establish the major relationships that are important, in and of themselves, and that provide the sensible, meaningful structure to which details are anchored. To aid in identifying the important interrelationships, the SME referred to the conceptual and procedural supporting structures and identified each instance of relationship, interpretation, or application, along with the conditions that influence the application of the principles. Products of these analytic decisions are illustrated in Figure 12.

2. Conceptual. In the case of the taxonomy, the epitome is simply the highest row or rows of the taxonomy, and the levels of elaboration are the lower rows, assigned primarily on the basis of convenience in meeting the daily class period or the unit a typical student can handle without being overloaded.

3. Procedural. The procedural epitome is a simplified and idealized version of the procedure. An example is shown in Figure 9. The various steps, branches, and conditions that influence the conduct or interpretation of the procedure are included primarily on the basis of the class period or the "bite" the student can handle.

Synthesizing

The use of this term reflects the model developer's intent to emphasize the wholeness of a subject, to ensure that the general nature and the important interrelationships are clear. The synthesizer is any kind of statement that begins instruction or that reinforces the learner's grasp of the essence of the subject and its most important interrelationships. The epitome that opens instruction of a subject or a topic within one of the levels of elaboration is a synthesizer. A synthesizer would also follow any period of instruction in which additional dimensions of relationships were clarified or expanded across topics or through levels. The synthesizer expresses the course writer's conception of the essential nature of the subject matter as best he can conceive and state it. It differs from the overview, which tends to be a prelisting or outline of a topic, and from a summary, which is a postlisting of the elements of the topic.

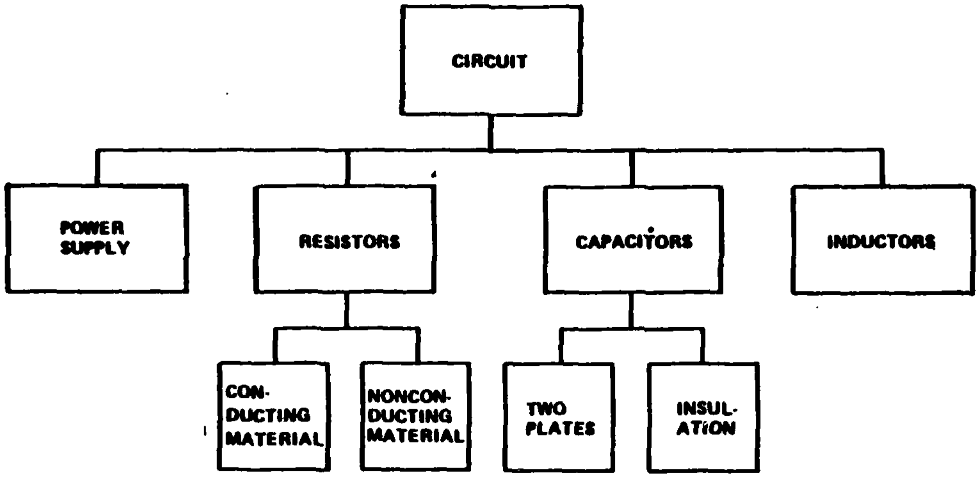
Summarizing

This term is used in its conventional meaning. The model emphasizes the systematic use of summaries following each topic and each completed level of elaboration.

Preparation of Instruction

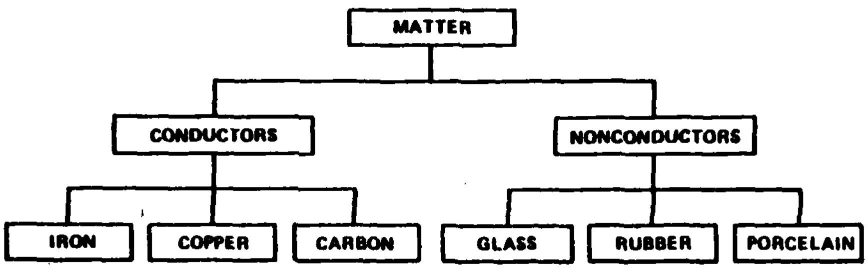
A systematic procedure for preparing instruction for the elements of Figure 12 is given for the epitome (Figure 20) and the first level of elaboration (Figures 21-23). The

procedures are repeated for the other levels of elaboration. In Figures 21-23, the word "synthesizer" may mean either a topic or subtopic epitome, a restatement of an important idea including the material added in each new topic, or a restatement or reinforcement of a connection between one topic and another. The intent of Figures 20-23 is to guide the designer and the SME in preparing instructional materials for each entry in Figure 12.



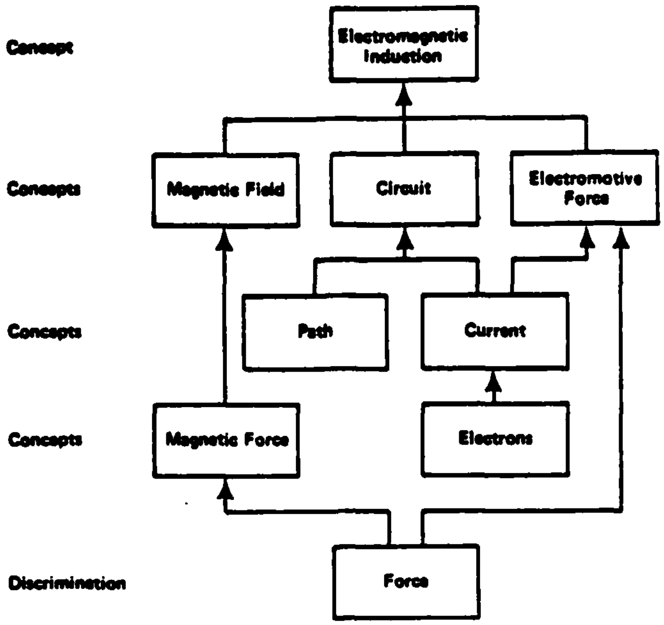
Key: The line between two boxes on different levels means that the lower box is a part of the higher box.

Figure 1. A parts taxonomy as a conceptual supporting structure.



Key: The line between two boxes on different levels means that the lower box is a kind of the higher box.

Figure 2. An example of a kinds-taxonomic structure.



Key: The arrow between two boxes on different levels means that the lower box must be learned before the higher box can be learned.

Figure 3. An example of an hierarchical learning structure.

$$R = \frac{E}{I}$$

Key: The mathematical symbols show the logical-theoretical relations between resistance (R), electromotive force (E), and current (I) in a simple series DC circuit. Empirically determined values may vary slightly from the logical.

Figure 4. An example of a logical-theoretical structure.

Always start at the end of the resistor which has the least body color showing. The color of the first band tells the first number in the resistance value and the second band tells the second digit. The third band indicates the number of zeros to be used behind the second digit.

The fourth band also has a special significance. It tells how accurately the resistor was manufactured. This band shows the resistor's tolerance as a percentage of the resistance value.

To summarize, the color bands on the resistor indicate values as follows:

First band--first significant digit

Second band--second significant digit

Third band--decimal multiplier (number of zeros to add)

Fourth band--tolerance

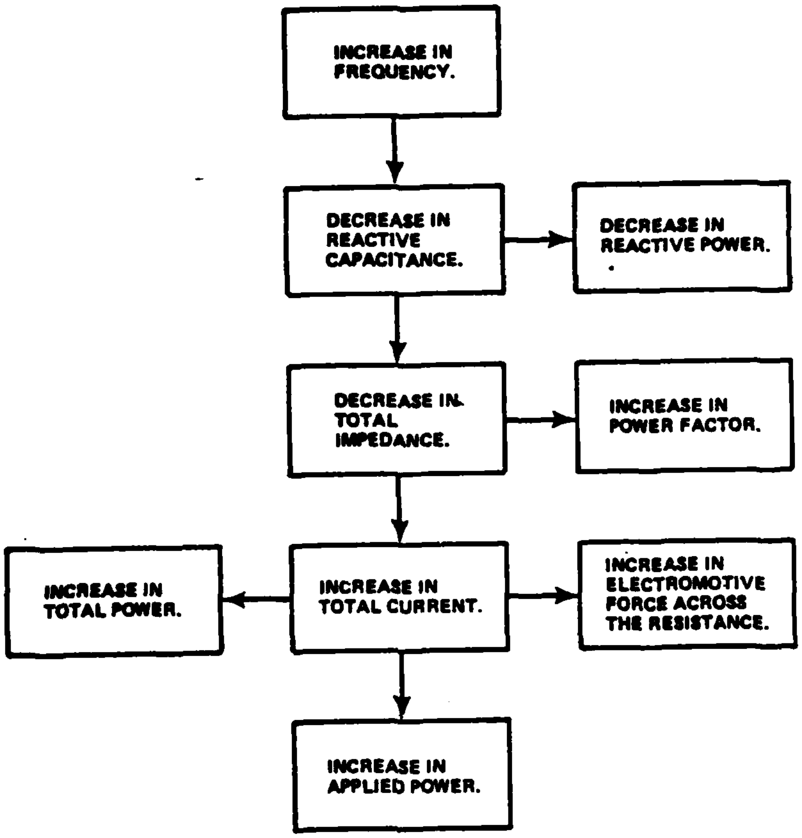
The Color Code

The standard color code used for these bands is shown below, along with a nonsense sentence to help you remember the values.

COLOR	NUMBER	TOLERANCE	SENTENCE
Black	0		Bad
Brown	1		Boys
Red	2		Race
Orange	3		Our
Yellow	4		Young
Green	5		Girls
Blue	6		Behind
Violet	7		Victory
Gray	8		Garden
White	9		Walls
Gold	.1[a]	± 5%	Get
Silver	.01[a]	± 10%	Started
No Color		± 20%	Now

[a]When this color is used as a multiplier (third band).

Figure 5. An example of a conceptual supporting structure.



Key: The arrow between two boxes means that the change in one box causes the change in the other box to occur.

Figure 6. An example of an empirical theoretical structure.

$I = \frac{E}{R}$

- $P = EI$
- $C = \frac{Q}{E}$

Factors affecting:
inductance
capacitance

$$\left.\begin{array}{l} E_a = E_{R1} + E_{R2} + \ldots \\ I_T = I_{R1} = I_{R2} = \ldots \\ R_T = R_1 + R_2 + \ldots \\ L_T = L_1 + L_2 + \ldots \\ C_T = \dfrac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots} \end{array}\right\} \text{Series}$$

- $$\left.\begin{array}{l} E_a = E_{R1} = E_{R2} = \ldots \\ I_T = I_{R1} + I_{R2} + \ldots \\ R_T = \dfrac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots} \\ L_T = \dfrac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \ldots} \\ C_T = C_1 + C_2 + \ldots \end{array}\right\} \text{Parallel}$$

$P_T = P_{R1} + P_{R2} + \ldots$

- $P_p = P_s$

$\frac{Ep}{Es} = \frac{Np}{Ns} = \frac{Is}{Ip}$

$X_L = 2\pi f L$

$X_C = \frac{1}{2\pi f C}$

$\text{Effic} = \frac{P\ \text{out}}{P\ \text{in}}$

$P_f = \frac{\text{True } P}{\text{Appar. } P}$

$T_c = RC$

Left-hand rule

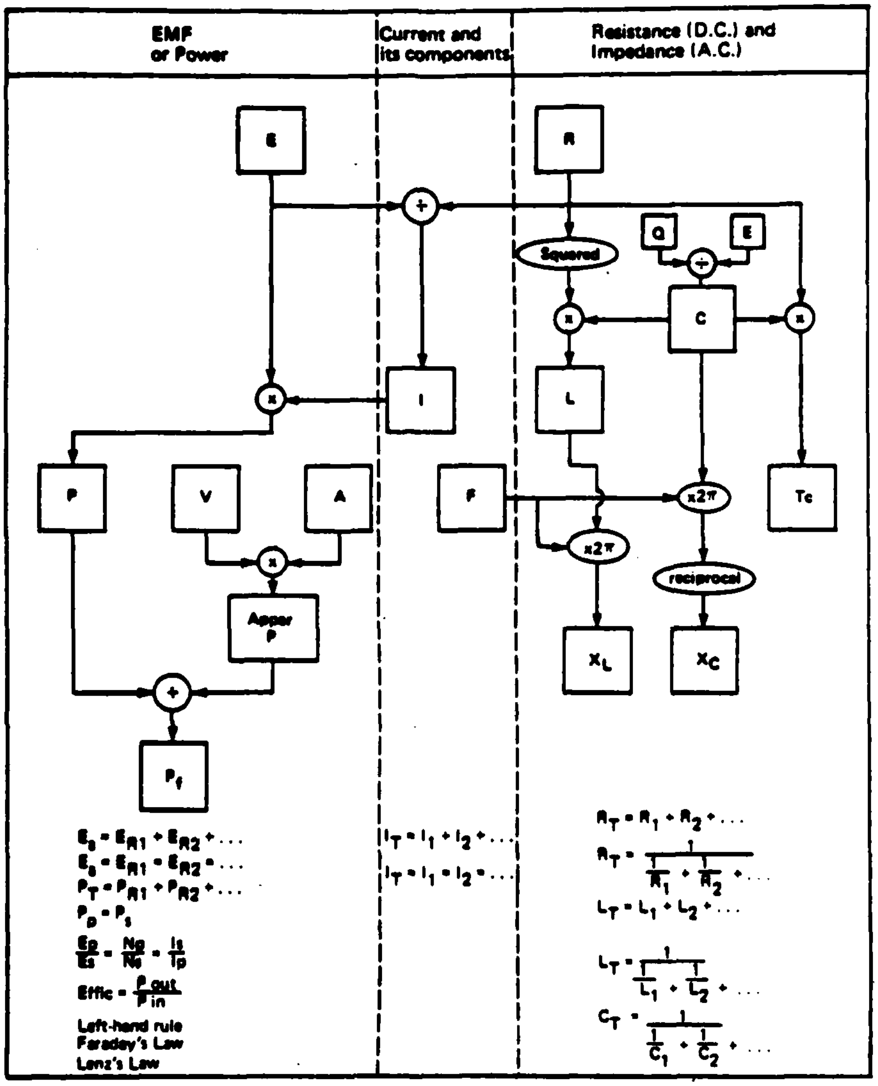
Faraday's Law

Lenz's Law

Phase and power relationships

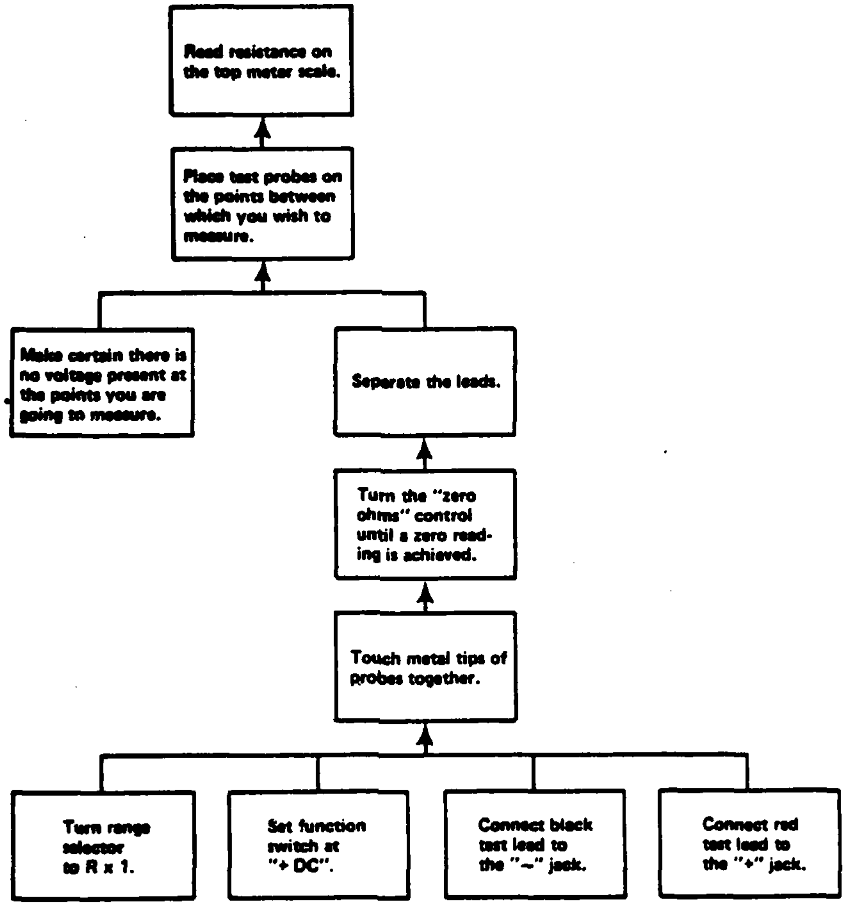
Key: This figure is intended to be exemplary. It is beyond our intent and the scope of our funding to include all of the content that should be taught in the BE/E course.

Figure 7. A list of the principles that the trainee should know by the end of the BE/E course.



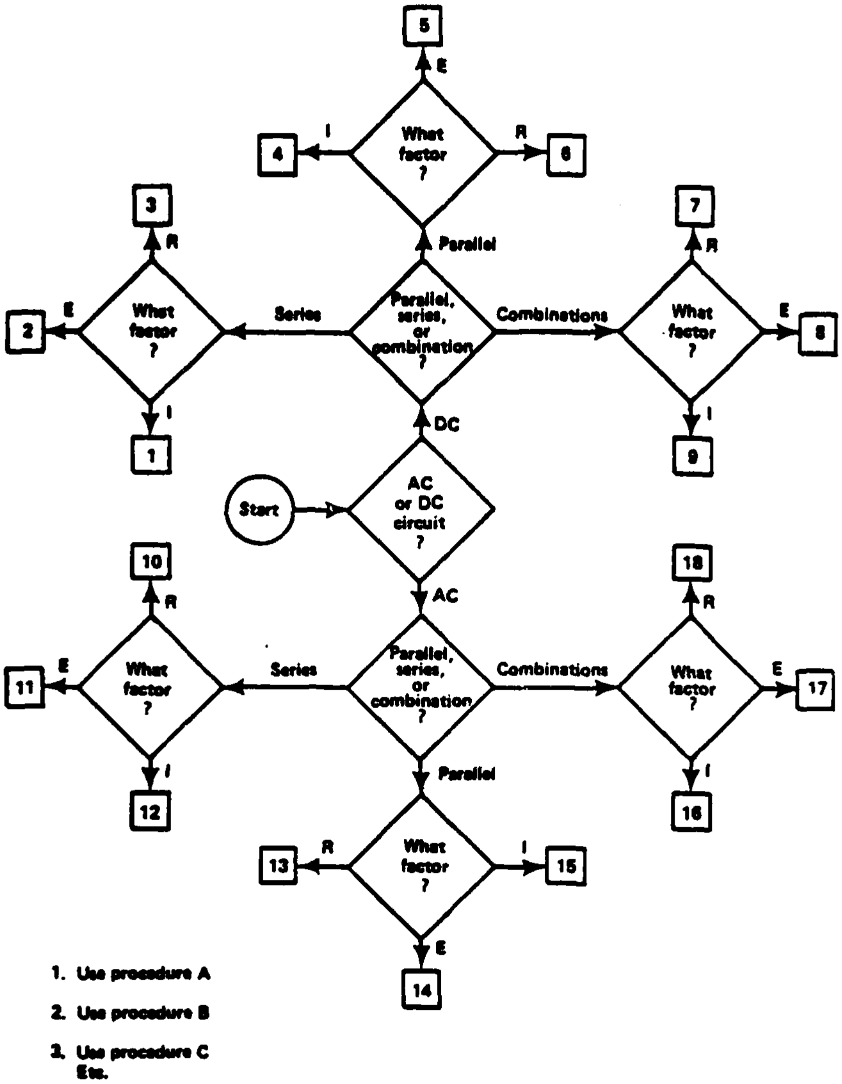
<u>Note</u>. The categorization of principles as elaborations of just one of the three parts of the epitome--E, I, or R--is not entirely accurate because most of the principles elaborate to some extent on two or all three of the parts. Also, this figure is intended to be exemplary. It is beyond our intent to include all of the principles that ought to be taught in the BE/E course.

Figure 8. A diagram expanding the theoretical relations among the principles of Figure 7.



Key: The arrow between two boxes on different levels means that the lower box must be performed before the higher box can be performed. Boxes on the same level can be performed in any order.

Figure 9. An example of a procedural prerequisite structure.



Key: Each diamond represents a decision point in the selection of the appropriate procedure for measuring an aspect of electricity in a circuit.

Figure 10. An example of a procedural decision structure.

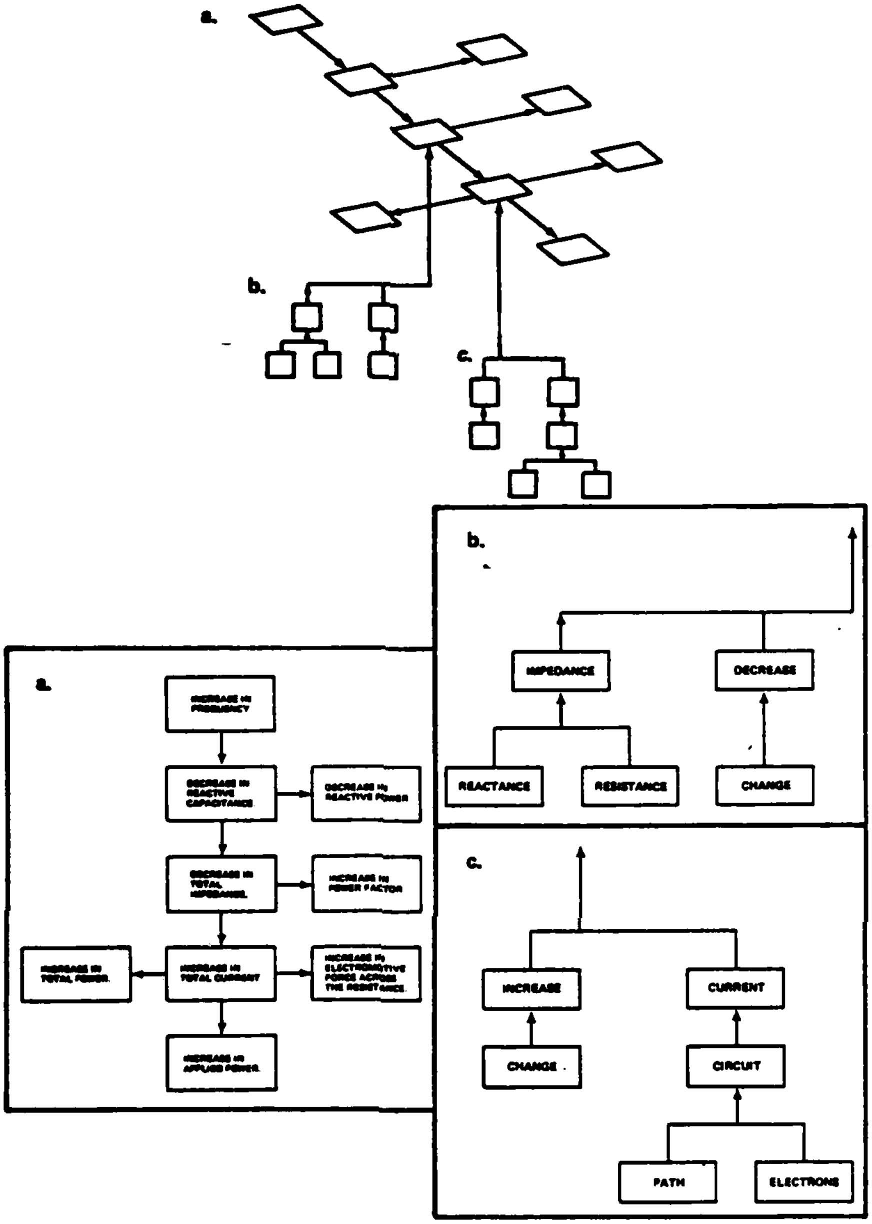


Figure 11. Part of a nested multistructure showing two learning prerequisite structures as supporting structures for a theoretical orientation structure.

Structural strategy component	Part of theoretical orientation structure included	Part of conceptual parallel structure included	Conceptual supporting structures included	Procedural supporting structures included	Learning prerequisite structures included
Epitome	$I = \frac{E}{R}$	DC simple		Manipulating I Measuring E, I, and R Calculating E, I, R Troubleshooting	E, I, R, Scientific notation shorts, opens
Primary Level of Elaboration 1.	$P = EI$	DC AC simple	Power Supply (kinds) Electromagnetic inductor (parts)	Calculating P	DC, AC, magnetism, electromagnetic induction, counter EMF, generator, P
2.		AC simple	Frequency (kinds)	Manipulating frequency	Frequency, phase
3.	$C = \frac{Q}{E}$ Factors affecting inductance capacitance	AC simple	Resistor (kinds) Capacitor (kinds) Inductor (kinds)	Measuring L, C Reading resistor, inductor, capacitor, values	L, C, resistor, capacitor, inductor, induction
Secondary Level of Elaboration 1.1	$E_a = E_{R1} + E_{R2} \cdots$ $P_T = P_{R1} + P_{R2} + \ldots$	DC AC series		Calculations	Series circuits, applied voltage
2.1	$I_T = I_{R1} = I_{R2} \cdots$	DC AC series		Calculations	
3.1	$R_T = R_1 + R_2 + \ldots$ $L_T = L_1 + L_2 + \ldots$ $C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots}$	DC AC series		Calculations Troubleshooting	
1.2	$E_a = E_{R1} = E_{R2} \cdots$ $P_T = P_{R1} + P_{R2} + \ldots$	DC AC parallel		Calculations	Parallel circuits
2.2	$I_T = I_{R1} + I_{R2} + \ldots$	DC AC parallel			
3.2	$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots}$ $L_T = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \ldots}$ $C_T = C_1 + C_2 + \ldots$	DC AC parallel			Equivalent resistance
Tertiary Level of Elaboration 1.1.1 (2.2.1)	$P_p = P_s$ $\frac{E_p}{E_s} = \frac{N_p}{N_s}$ $\text{Effic.} = \frac{P\ out}{P\ in}$	DC AC Combination	Transformer (parts)	Calculations	Transformers, transformer efficiency, turns, primary, secondary, load, rectifier, combination circuits
2.1.1 (2.2.1)	$\frac{N_p}{N_s} = \frac{I_s}{I_p}$	DC AC Combination		Calculations	
3.1.1 (3.2.1)	$T_c = RC$ $X_L = 2\pi fL$ $X_C = \frac{1}{2\pi fC}$	DC AC Combination		Calculations Measuring X_L, X_C	X_L, X_C, RC time constant
1.1.2 (1.2.2)	$P_f = \frac{\text{True P}}{\text{Appar. P}}$ Phase & power relationships	DC AC Combination		Calculations	Appar. P, P_f, vectors
1.1.3 (1.2.3)	Left hand rule Faraday's Law Lenz's Law	DC AC Combination			

Note. This figure is intended to be exemplary. It is beyond our intent and the scope of our funding to include all of the content that should be taught in the BE/E course.

Figure 12. Theoretical and supporting structures.

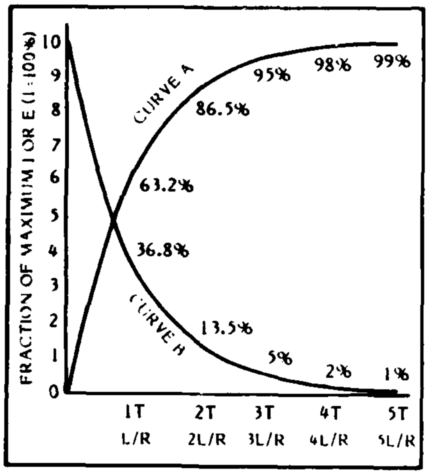
Time Constants

(Time constants are usually stated in milliseconds or microseconds.)

Our computation shows that one time constant is equal to 200 milliseconds; so, between T0 and T1, 0.2 seconds will elapse.

> As all the time constants for any given circuit are equal, compute how long it will take (in seconds) for current in the above circuit to reach its maximum value.

Since it always takes current five time constants to reach maximum, multiplying the TC by 5 (0.2 x 5 = 1 second), 1 second will be needed for current to reach its maximum value.



Similarly, it will take five time constants for current to decay from its maximum value to zero for all practical purposes. As the time constant for this circuit is 0.2 seconds, it will take current 1 second to decay from its maximum value back to zero. The only way you can change the time constant of a circuit is to change the value of R or L.

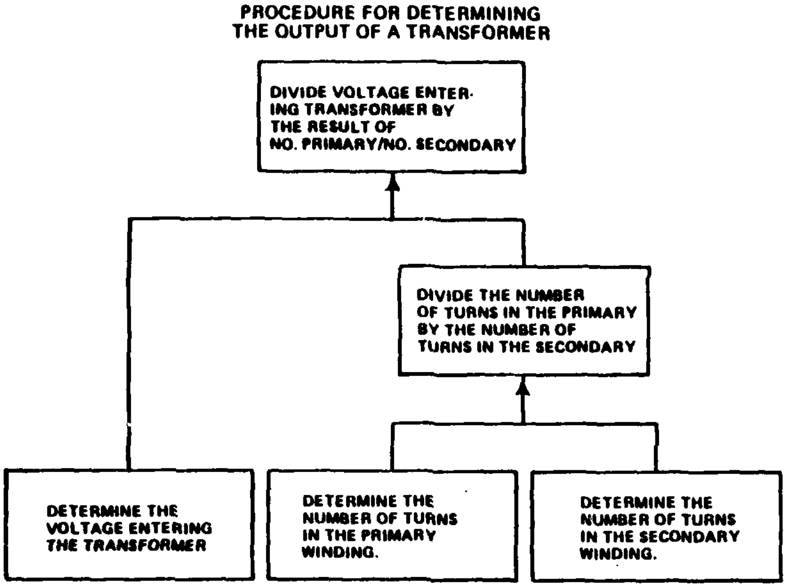
The illustration here shows the rise and decay curves the current follows from T0 to T5.

Figure 13. Example of a procedural supporting structure.

TYPES OF ELECTRICITY

TYPES OF CIRCUITS	DC	AC
Simple	DC in simple circuits	AC in simple circuits
Series	DC in series circuits	AC in series circuits
Parallel	DC in parallel circuits	AC in parallel circuits
Combination	DC in combination circuits	AC in combination circuits

Figure 14. Types of circuits as a supporting structure.



Key: The arrow between two boxes on different levels means that the lower box must be performed before the higher box can be performed. Boxes on the same level can be performed in any order.

Figure 15. A procedural prerequisite structure.

Reading Multiscale Meters

Interpreting the 500 ma, 100 ma, 10 ma, and 1 ma Scales

Look at the DC scale on your multimeter. Notice that there are *three rows* of numbers under the black DC arc, marked 0-250, 0-50, and 0-10. the meter scales used for DC current measurements are the 0-50 and 0-10 scales.

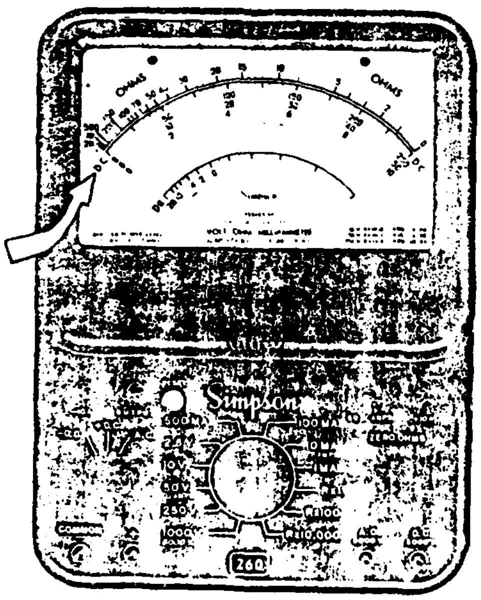
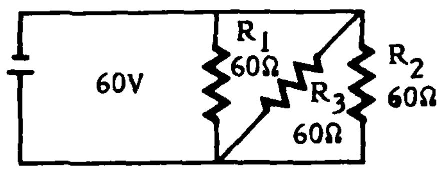


Figure 16. A prerequisite supporting structure.

Variational Analysis

A quick way to improve your understanding of how circuit quantities interact is to use variational analysis. In variational analysis, one value in a circuit is caused to change and the effect of this change on all other circuit quantities is examined. A table is made up listing all measurable values in a circuit, and arrows are used to show what changes take place. An arrow pointing upward indicates increase ($\uparrow$); an arrow downward, decrease ($\downarrow$); and a horizontal arrow, no change ($\rightarrow$). Variational analysis usually starts with an assumed change in either voltage or resistance, the quantities we can physically change in a circuit.

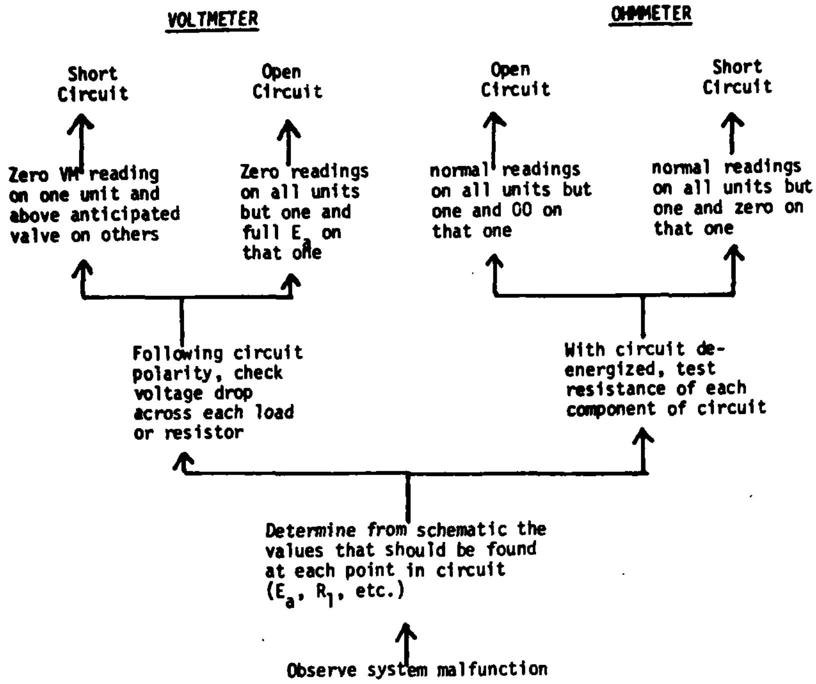
Here is an example of changing the applied voltage in a circuit from 60v to 120v.



	$E_a \uparrow$
I_T	$\uparrow$
R_T	$\rightarrow$
P_T	$\uparrow$
I_{R1}	$\uparrow$
I_{R2}	$\uparrow$
I_{R3}	$\uparrow$
E_{R1}	$\uparrow$
E_{R2}	$\uparrow$
E_{R3}	$\uparrow$
R1	$\rightarrow$
R2	$\rightarrow$
R3	$\rightarrow$

First, show in the top square the value which has changed and whether it increases or decreases; then mark in arrows which show how the remaining values are affected. You need not work out values unless you are uncertain of the answer; you should be able to fill in the blanks from your knowledge of Ohm's Law and circuit rules.

Figure 17. Example of procedural theoretical supporting structure.



Note. In circuits protected by fuses, a short usually causes the fuse to burn out, adding an open to the original short.

Figure 18. Example of a procedural decision structure (Troubleshooting series circuits).

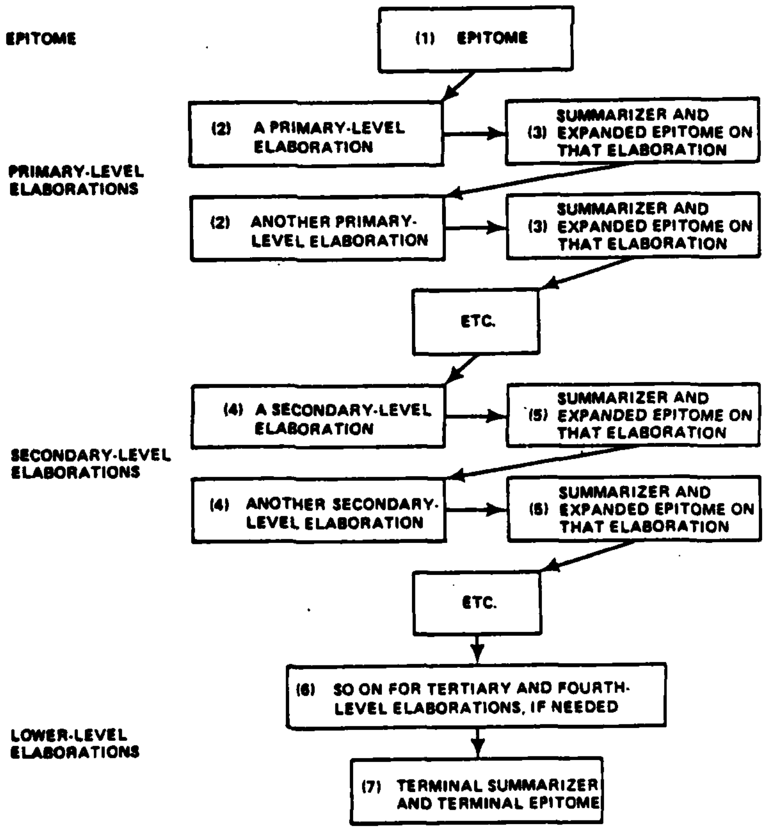


Figure 19. An illustration of the elaboration model of instruction.

Initial synthesizer: $I = \frac{E}{R}$, Parallel con. structure

Instruction on E, I, and R, DC (concepts)

- generality-instance-practice format

Instruction on $I = \frac{E}{R}$ (Principle)

- generality-instance-practice format

Initial synthesizer scientific notation

Instruction on scientific notation

- generality-instance-practice format

Summarizer/synthesizer on scientific notation

Initial synthesizer on measuring E, I, R

Instruction on measuring E, I, R

- generality-instance-practice format

Summarizer/synthesizer for measuring E, I, R

Initial synthesizer on calculating E, I, R

Instruction on basic algebra

- generality-instance-practice format

Summarizer/synthesizer for basic algebra

Instruction on calculating E, I, R

- generality-instance-practice format

Summarizer/synthesizer on calculating E, I, R

Summarizer and expanded epitome synthesizer
($I = \frac{E}{R}$ and its supporting structures)

Figure 20. An instance of an epitome.

PRIMARY LEVEL OF ELABORATION
First Individual Elaboration

Initial synthesizer: P = EI,

Instruction on P (concept)

- generality-instance-practice format

Instruction on P = EI (principle)

- generality-instance-practice format

Initial synthesizer on parallel conceptual structure

Instruction on kinds of power supply (AC - DC)

- generality-instance-practice format

Summarizer/synthesizer on kinds of power supply

Initial synthesizer
Instruction
Summarizer/synthesizer
} on magnetism, electromagnetic induction, counter EMF, and generators (concepts).

Initial synthesizer on parts of electromagnetic inductors

Instruction on parts of electromagnetic inductors (G-I-P format)

Summarizer/synthesizer on parts of electromagnetic inductors

Initial synthesizer on calculating P

Instruction on calculating P (G-I-P format)

Summarizer/synthesizer on calculating P

Summarizer and expanded epitome.

Figure 21. A first primary level elaboration.

PRIMARY LEVEL OF ELABORATION
Second Individual Elaboration

Initial synthesizer on kinds of frequency

Instruction on kinds of frequency

- generality-instance-practice format

Summarizer/synthesizer on kinds of frequency

Initial synthesizer
Instruction
Summarizer/synthesizer
} on phase

Initial synthesizer
Instruction
Summarizer/synthesizer
} on manipulating frequency

Expanded epitome showing the context of frequency within the orientation structure

Figure 22. A second primary level elaboration.

PRIMARY LEVEL OF ELABORATION
Third Individual Elaboration

Initial synthesizer: $C = \frac{Q}{E}$

Instruction on induction, L, C, Q, E (concepts)

- G-I-P format

Instruction on $C = \frac{Q}{E}$ (principle)

- G-I-P format

Initial synthesizer Instruction Summarizer/synthesizer	on measuring L, C
Initial synthesizer Instruction Summarizer/synthesizer	on calculating C
Initial synthesizer Instruction Summarizer/synthesizer	on kinds of elect. components (resistors, capacitors, inductors) and on kinds of those kinds
Initial synthesizer Instruction Summarizer/synthesizer	on factors affecting inductance and capacitance

Summarizer and expanded epitome

Figure 23. A third primary level elaboration.

RESULTS OF MODEL APPLICATION

The primary question is whether application of the model changes the organization of a training course. To answer this question, the course content identified in Figure 12 should be compared with that in Figure 24, an abridgement of the sequence of topics included in BE/E CF 69. Since this comparison is made only to answer the question concerning possible differences in organization, no implications should be drawn concerning the merits of the two forms.

BE and E Module Number	Part of theoretical orientation structure included	Part of conceptual parallel structure included	Conceptual supporting structures included	Procedural supporting structures included	Learning prerequisite structures included
1		Simple circuit		Measuring I	I, simple circuit, basic algebra, scientific notation
2	Left hand rule	DC, AC, (series)		Measuring E	E, magnetism, electro magnetic induction, generator
3		Simple DC	Resistor (kinds)	Measuring R, reading resistor values	R, resistor
4	$I_1 = I_2 = \cdots$ $E_a = E_{R1} + E_{R2} + \cdots$	Series, (parallel) DC		Measuring I, E Calculating E_a	Series circuit, (parallel circuit), applied voltage
5	$I = \frac{E}{R}$ $P = EI$	Series, DC		Calculating E, I, R, P Manipulating I Troubleshooting	P, short circuits, open circuits
6	$E_a = E_{R1} = E_{R2} = \cdots$ $I_T = I_{R1} + I_{R2} + \cdots$ $R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots}$ $R_T = R_1 + R_2 + \cdots$ $P_T = P_{R1} + P_{R2} + \cdots$	Parallel		Calculations Troubleshooting	Parallel circuit, equivalent resistance
7		Combination		Calculations Designing a voltage divider	Combination circuits, voltage dividers
8	Left hand rule Faraday's Law Lenz's Law Factors affecting inductance	AC	Inductor (kinds) Electromagnetic inductor (parts)	Calculating L	L, induction, inductor, counter EMF
9*	$L_T = L_1 + L_2 + \cdots$ $L_T = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \cdots}$ $X_L = 2\pi fC$	All		Calculations Reading inductor values	T_C, X_L
10	$\frac{Ep}{Es} = \frac{Np}{Ns} = \frac{Is}{Ip}$ $Pp = Ps$ $\text{Effic} = \frac{P\ out}{P\ in}$	AC	*Transformer (parts)*	Calculations	Transformer, turns, primary, secondary, load, transformer efficiency, rectifier
11	$C = \frac{Q}{E}$ Factors affecting capacitance $C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \cdots}$ $C_T = C_1 + C_2 + \cdots$ $X_C = \frac{1}{2\pi fC}$ $P_f = \frac{\text{True P}}{\text{Appar. P}}$ Phase and power relationships	All	Capacitor (kinds)	Calculations Reading capacitor values	C, capacitance, capacitor, X_C, phase, RC time constant, appar. P, P_f

Note. This figure does not contain all of the content in the BE/E course. It is intended to give an indication of the nature of the organization of this version of the course.

Figure 24. An outline of the organization of a BE/E course.

The first point is that there is nothing in the prior course that corresponds to an orientation structure. In the organization derived from the model, Ohm's Law is the orientation structure. Nearly all the following material elaborates the relationships and applications of this theoretical structure. In CF 69, Ohm's law is not introduced until module 6.

The differences between the columns headed "conceptual supporting structures" and "procedural supporting structures" are relatively slight. Concepts introduced in modules 8-14 in CF 69 were included earlier as prerequisites in the outline derived from the model. This follows from the elaboration of Ohm's Law material, which, as noted earlier, is regarded as the heart of the course. No essential differences exist in the "conceptual parallel structures" column because there is very little material in this category.

The most apparent important difference in the two forms of organization is in the immediate introduction of Ohm's Law in the form derived from the model, and in the use of this structure as an organizing principle throughout the rest of the basic part of the course.

DISCUSSION

The model is intended to improve training material by providing an alternative to the detail-centered approach that creates learning, retention, and application problems for many students. There are some admonitory lessons, which can be drawn from the model, that could improve the quality of written instructional materials:

1. A unifying conception should be developed for any course before the training materials are prepared. The elaboration model proposes using an orientation structure[5] as a desirable alternative to the diffuse, detail-centered approach.

2. The materials analysis steps of the elaboration model and the simple and reasonable procedure for creating taxonomies should be considered to help designers select and organize important conceptual subject mater. It also appears probable that the taxonomizing procedure itself is something that should be learned as a means to orderly thought and organization of training course subject matter.

3. Instruction should get right to the major business of the course without verbiage or trivia. The epitome helps designers achieve their initial focus on the major objective(s) and makes the learner's task clear to him.

4. Designers should follow the whole-to-part approach whenever possible, as it reduces unnecessary detail and provides context for relevant detail.

5. Designers should be aware of the different types of structures--orientation and supporting, conceptual, procedural, and theoretical. With these concepts in mind, they should be better able to direct their search through the universe of potential content to select the material that is most appropriate for the course.

---

[5]An intelligently conceived performance objective (not an atomistic behavioral objective) could serve as an orientation structure. In the BE/E course, for example, variational analysis as a major performance objective would have a powerful beneficial influence in selecting and organizing material for modules 1-14.

This approach offers a welcome alternative to today's course development procedures that confront the designer with a task list and some frequency-criticality data from which he is supposed to develop a job-relevant course. Except for a few basic skills, such as soldering or reading wiring diagrams, the job-task approach is usually impossible to implement at the entry level because of training time limits and the amount of support needed. Since the designer cannot simply list the tasks to be learned, he must rely on his own logical analyses to formulate the materials. It is not surprising that the designer sometimes resorts to the detail-centered approach, tedious exposition, and "nit picking" tests that are so prevalent that their effectiveness is rarely questioned.

This model offers an alternative approach for selecting, organizing, and emphasizing training material. However, the model in its present form is not complete; further development is necessary before it can be applied by military users. The procedures must be clarified and made more explicit as follows:

1. Supporting structures are described only as "less inclusive" than orienting structures. This description leaves a major decision to the duty SME. Clearer criteria and directions should be provided.

2. The model states that levels of elaboration are differentiated "by deciding upon dimensions of complexity that represent the basis upon which different levels elaborate on the epitome or on each other." Specific directions should be provided in place of this abstract statement.

3. The order of priority of the various possible supporting structures within each level of elaboration is not now addressed; criteria or directions are needed.

4. Instructions should be written to specify the use of relationships in determining sequence within and across levels of elaboration.

5. The priority of prerequisite structures should be clarified; the model implies that they occur at the lowest level of elaboration, whereas they may be needed from the first epitome on.

The model in its present form is intended for the revision of existing course materials; that is, it is aimed at instructional efficiency rather than validity, but this important distinction may not occur to all potential users. Using the model without first evaluating the real course objectives could produce instruction that more efficiently misses its target. For the immediate future, it may suffice to warn the user that validity is a separate and prior concern. For the long run, the model should be revised to apply to task description and analysis matter--not existing lessons--to achieve its greatest value.

CONCLUSIONS

The structural strategies model described herein is an attempt to improve effectiveness of instruction by specifying methods to identify and organize important relationships in subject matter. Although some of the procedures and concepts have value for instructional development, the model is not fully adequate in its present form.

REFERENCES

Chief of Naval Technical Training. Procedures for the planning, design, development, and management of Navy technical training courses (CNTT A-10). April 1976.

Chief of Naval Education and Training. Procedures for instructional systems development (NAVEDTRA 110). July 1979.

Reigeluth, C. M., Merrill, M. D., Wilson, B. G., and Spiller, R. T. Final report on structural strategy diagnostic profile project (CW-0245-31). San Diego: Courseware, Inc., July 1978.

Smith, J. P., & Bilinski, C. R. Practical problems in the implementation of individualized instruction (unpublished report). San Diego: Navy Personnel Research and Development Center (undated).

Wulfeck, W. H., II, Ellis, J. A., Richards, R. E., Wood, N. D., & Merrill, M. D. The instructional quality inventory. I. Introduction and overview (NPRDC Spec. Rep. 79-3). San Diego: Navy Personnel Research and Development Center, November 1978. (AD-A062 493)

APPENDIX

KNOWLEDGE STRUCTURE

KNOWLEDGE STRUCTURE

Introduction

The motivation for attempting to analyze knowledge into structures is that, if different structures can be reliably identified, efficient and economical instructional prescriptions can be established regardless of the particular content or subject matter.

Knowledge Structure

The model developer proposes that verbal knowledge and the verbal representation of procedural knowledge is, in essence, conceptual. There are many different kinds of things and events in the world; these are termed "referents" (Figure A-1). When referents are sorted into "kinds" based on shared attributes, they are called "concepts." When certain things are done to concepts, they are called "constructs" (Figure A-2). When constructs are related in certain ways, they become "structures." The "things done" to concepts are called "operations." The following three operations are used with referents and concepts to yield constructs:

1. Descriptive operation—The combination of two or more concepts to produce a new concept.

2. Productive operation—A change process such as composition or decomposition.

3. Identity operation—no change.

Knowledge is further described as propositional or "conceptual," and calculational/algorithmic or "nonconceptual."[1] These descriptors and the types of operations are then combined in a matrix, viz:

		Type of Operation		
		Identity	Descriptive	Productive
Type of Knowledge	Conceptual			
	Nonconceptual			

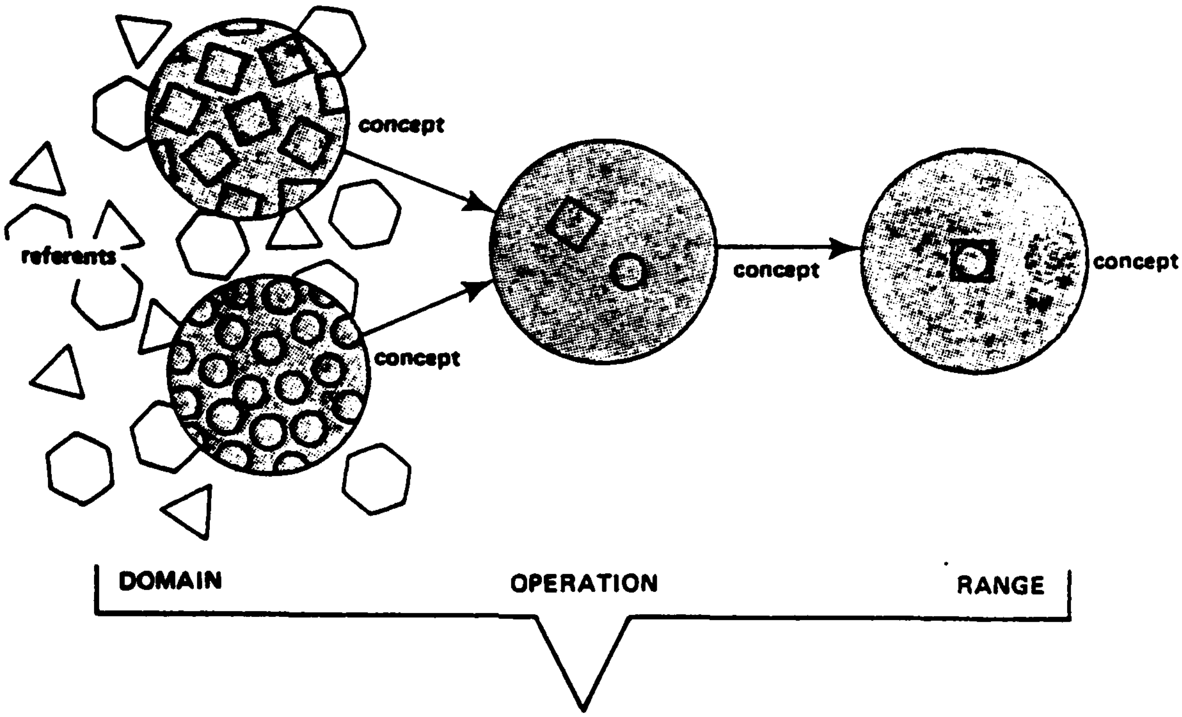
A unit of knowledge that is both descriptive and conceptual concerns attributes of concepts; if it is productive and conceptual, it concerns change. Descriptive and nonconceptual refers to the grouping of similar things,[2] while the nonconceptual productive concerns order of events, as of the steps in a procedure. Since, by definition, identities are nonconceptual, the conceptual-identity cell is eliminated, as shown below:

---

[1] These terms did not originate with the model developer, but confusion arises when they are used in other senses. In another paper, the conceptual is equated with "meaningful"; and the nonconceptual, with "rote."

[2] How a concept can be conceptual but a set of concepts nonconceptual is one of the oddities resulting from the unfortunate problems of categorizing mentioned above.

COMPONENTS OF SUBJECT MATTER



REFERENT (INSTANCE). A referent (or Instance) is an object, event, or symbol which exists, or could exist, in our real or imagined environment.

CONCEPT. A concept is a set of common characteristics (attributes) referenced by a particular name or label, that can be applied to a set of referents (instances of that concept).

OPERATION. An operation is a function set or a set of operators which specifies a particular mapping between a domain and a range.

DOMAIN. A domain is a set of referents upon which the operation acts or to which it is applied.

RANGE. A range is a set of referents which results from the application of an operation to a domain.

CONSTRUCT. A construct is a structure consisting of a domain, an operation, and a range.

Figure A-1. The composition of a content construct.

CONSTRUCT

Fact

The symbol shown is used to represent a vacuum tube on a schematic diagram of an electronic circuit.

Subset

Parallel circuits, series circuits, and combination circuits are three kinds of circuits.

Concept

A circuit is at resonance when reactive capacitance and reactive inductance are present in equal amounts (in a series RLC circuit).

Step

To "zero" the ohmmeter:
1. Turn range selector to desired setting.
2. Touch probes together.
3. Adjust ohms control until a zero reading is achieved.

Principle

An increase in frequency in a AC circuit produces a decrease in total current and an increase in total impedance.

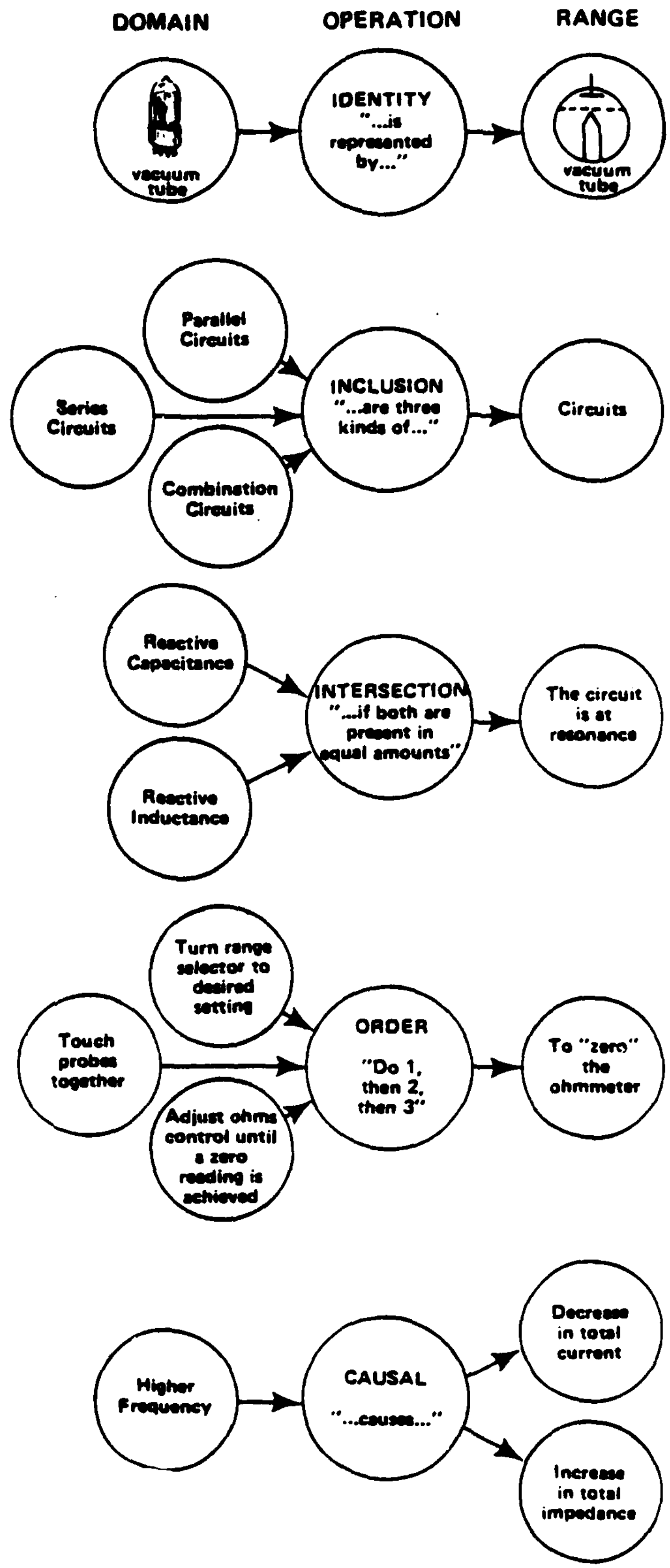


Figure A-2. An example of each of the five kinds of constructs.

	Type of Operation		
Type of Knowledge	Identity	Descriptive	Productive
Conceptual	/////	Attribute	Change
Nonconceptual	Identity	Inclusion	Order

The cell descriptors are related to more familiar terms (i.e., facts, concepts, subsets, principles, and procedures), as shown below:

Elemental Operations

	Type of Operation		
Type of Knowledge	Identity	Descriptive	Productive
Conceptual	/////	Attribute Concept	Change Principles
Nonconceptual	Identity Fact	Inclusion Subset	Order Procedures

Turning now to structures (as contrasted to constructs), these result from relating three or more constructs in some important way. Relations are described in the same terms as operations:

	Type of Operation		
Type of Knowledge	Identity	Descriptive	Productive
Conceptual			
Nonconceptual			

The combination of types of knowledge and types of operations results in several new knowledge categories:

	Type of Operation		
Type of Knowledge	Identity	Descriptive	Productive
Conceptual	/////	Learning Prerequisite	Causal
Nonconceptual	No Relation	Super/Co/Sub/Ordinate	Procedural Prerequisite

These categories also may be provided with familiar instances:

Type of Knowledge		Type of Operation: Identity	Descriptive	Productive
	Conceptual	/////	Learning Prerequisite Learning Hierarchy	Causal Theory
	Nonconceptual	None Lists	Super/Co/Sub/Ordinate Taxonomy	Procedural Prerequisite Procedural Hierarchy

The dual use of the word "operation," although unfortunate, is supported by different definitions. The first usage refers to what is done to referents to make them into concepts; and the second, to what is done with constructs to make them into structures. Combining the matrices for both elemental operations and elemental relations produces the model developer's classification scheme:

		Constructs		Structures	
		Operation	Construct	Relation	Structure
Type of Operation	Type of Knowledge				
Identity	Nonconceptual				
Descriptive	Nonconceptual				
	Conceptual				
Productive	Nonconceptual				
	Conceptual				

Here, the operations and relations are added:

		Constructs		Structures	
		Operation	Construct	Relation	Structure
Type of Operation	Type of Knowledge				
Identity	Nonconceptual	Identity		-----	
Descriptive	Nonconceptual	Inclusion		Super/Co/ Sub/Ordinate	
	Conceptual	Attribute/ Component		Learning Prerequisite	
Productive	Nonconceptual	Order		Procedural Prerequisite	
	Conceptual	Change		Causal	

Finally, the instances are added to complete the taxonomy:

		Constructs		Structures	
		Operation	Construct	Relation	Structure
Type of Operation	Type of Knowledge				
Identity	Nonconceptual	Identity	Fact	-----	List
Descriptive	Nonconceptual	Inclusion	Concept	Super/Co/ Sub/Ordinate	Taxonomy
	Conceptual	Attribute/ Component	Subset	Learning Prerequisite	Learning Hierarchy
Productive	Nonconceptual	Order	Procedure	Procedural Prerequisite	Procedural Hierarchy
	Conceptual	Change	Principle	Causal	Theory/ Model

The result of all this is certainly different from current instructional technology. One example of such technology is Gagné's[3] list of learning types:

- Signal learning
- Stimulus-response learning
- Chaining
- Verbal association
- Multiple discrimination
- Concept learning
- Principle learning
- Problem solving

Another is Bloom's[4] cognitive domain taxonomy:

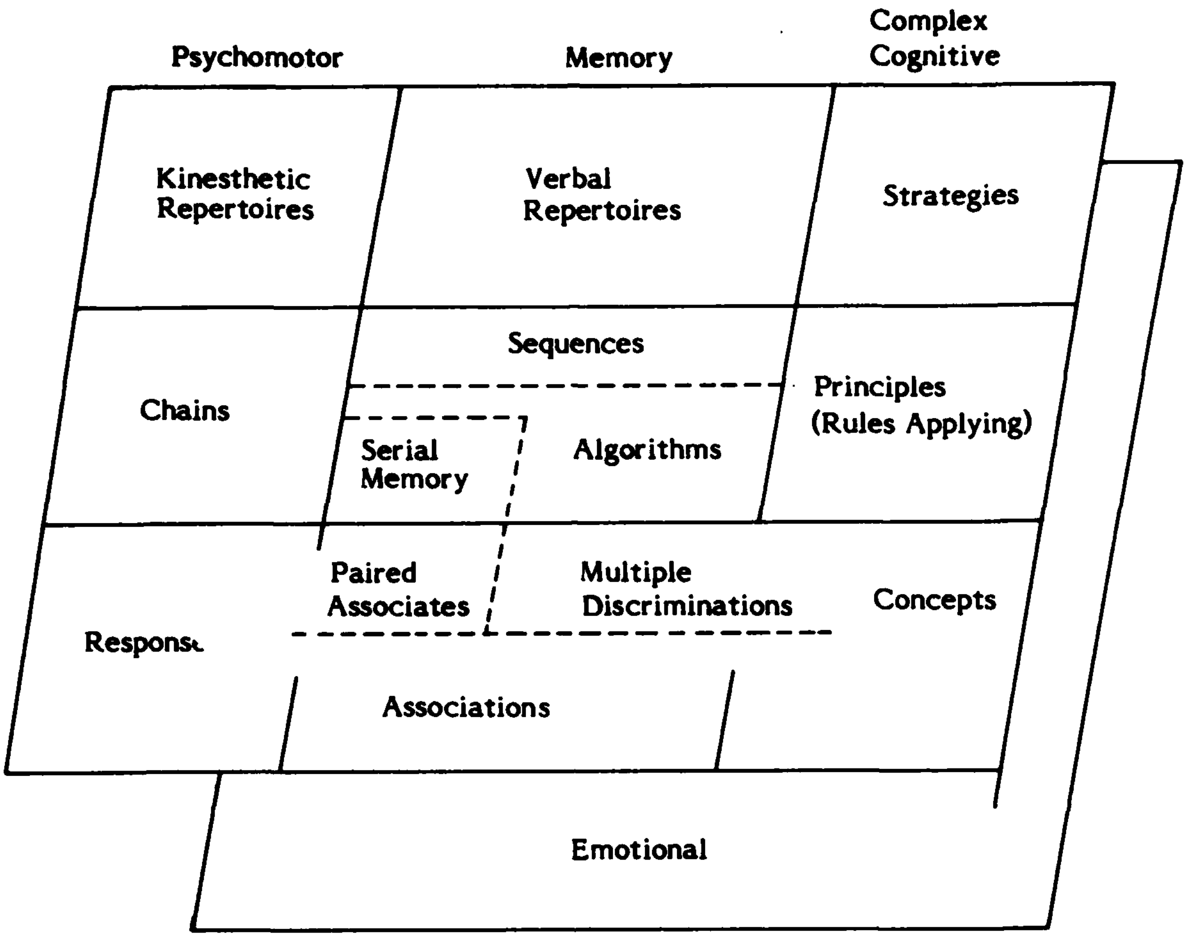
- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation

---

[3]Gagné, R. M. The conditions of learning. New York: Holt, Rinehart, and Winston, Inc., 1965.

[4]Bloom, B. S. Taxonomy of educational objectives. Handbook I. Cognitive domain. New York: Longmans, Green, and Co., 1956.

A third is the Tiemann-Markle elaboration[5] of Merrill's revision of Gagné's eight types of learning:



Now, the question may be asked: "Can different teaching or other instructional procedures be reliably and prescriptively associated with the various cells?" Further research and development are needed to answer this question.

[5]Tiemann, P. W., & Markle, S. M. Remodeling a model: An elaborated hierarchy of types of learning. Educational Psychologist, Fall 1973, 10(3), 147-158.

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